Fourteen days ago, when on the Fraser River, eighty miles from here, I saw after sunset a very brilliant aurora borealis. I write this thinking there may be a repetition of the phenomena in England, in which case this note may possess interest.

G. W. LAMPLUGH

Victoria, Vancouver Island, October 13

Peculiar Ice Forms

THE ice structures observed by Mr. Woodd Smith (November 6, p. 5) are evidently the same as were described in vol. xxi. p. 396. I have often seen such fibrous masses since, under circumstances which left no doubt of their being mainly due to prolonged condensation of aqueous vapour from the air; the fibres, white like asbestos, and covered only by a very thin layer of earthy particles, rising from a hard subsoil. The absorption of aqueous vapour by the soil, especially on mountains, seems not yet to be duly appreciated, although it is proved by the many springs issuing at short distances below the summits, and has been insisted upon already in Er. Darwin's "Botan. Garden" and "Phytonomia" (chap. xi. 2). "Rainfall being the source of all water-supply" (NATURE, vol. xxx. p. 375) is a statement hardly to be maintained. W.

Freiburg, Badenia, November 8

Seismographs—An Apology

I AM just in receipt of the inclosed letter from Mr. Charles A. Stevenson, in which he claims the original idea of the actuating mechanism in the *horizontal component seismograph* I have lately described in these pages, and he includes a copy of his paper to justify his remarks. I therefore think it my duty to offer my apologies to him for not having given him full credit for his invention so far as it goes, although I have *unconsciously* done him wrong. Naples is unfortunately very badly off for modern scientific works and *Proceedings* of Societies, both as regards the National and the University libraries, and as far as I know no copy of Mr. Stevenson's paper exists in the town, except the one he has now sent me.

Perhaps I may be permitted to point out that Mr. Stevenson's seismograph, so far as it is described, would be almost useless for the following reasons:—

(1) The inertia of the upper glass plate would be insufficient not to be affected by the slight movement conducted through the ivory balls to it. This is the reason I use the very heavy lead disk.

(2) No earthquake shock is perfectly horizontal, so that Mr. Stevenson's instrument would only be fit to register the horizontal component of the earth-wave, and would fail to do this, since if the angle of emergence was appreciable it would be jerked up off its supports, and consequently would simply register a series of interrupted lines. This is why I introduced the upper balls and resistance plate.

(3) If the instrument was disturbed by an earth-wave of large amplitude, the registering arm would pass beyond the border of the smoked plate (unless the apparatus was of very great dimensions, so failing to fulfil the conditions of the British Association), where the needle would drop out, or fall so low as to prevent the return of the arm over the plate.

(4) If the earthquake was of some seconds' duration and composed of many varying movements, as is generally if not always the case, a network of irregular curves would remain on the glass that would be quite unintelligible.

If a thing is to be done, it is advisable to do it well, and it is less possible to have accurate registers of earthquake shocks than of the force and direction of the wind, barometric pressure, or any other meteorological phenomena. The requirements of the British Association with regard to expense, size, and portability of seismographs, will not permit anything like an accurate investigation of geodynamics.

In conclusion, should I have overlooked and appropriated the ideas of any other inventor, I shall be happy to fully acknowledge them if sufficient evidence is given (as in the above case) of priority of publication. H. J. JOHNSTON-LAVIS

November 7

45, *Melville Street, Edinburgh, November* 3

I NOTICED recently in NATURE (vol. xxx. p. 608) an article by you in which you describe a seismograph for recording earthquake shocks, which would appear to be your own invention from reading the paper. No doubt the method of making the record, springs, and upper balls are your own invention, but the *principle* on which the seismograph there described acts is, as far as I know, mine or my father's. I inclose the paper in which it was first described, and I would be glad to learn from you if you forestalled me. CHARLES A. STEVENSON

Dr. Johnston-Lavis, Naples

Fly-Maggots Feeding on Caterpillars

A FEW months ago I had a caterpillar of *Papilio erythronius*, which I found on a lemon-tree. I put it into a card-box, and fed it daily on lemon-leaves. The box was covered with cloth *tied tightly all round the opening*. After some days, the caterpillar fixed itself to the side of the box, and turned into a chrysalis in the usual way. One day on opening the box, instead of finding the chrysalis changing into its usual colours and markings, it was dark all over. A few days more, on re-opening the box, I found six fully-developed cream-coloured maggots at the bottom of the box. I was rather puzzled to conjecture how these maggots got into a box three inches high, with a bit of cloth tied all round the opening. I put the maggots into a little box with some earth under a tumbler. They immediately buried themselves in the earth. In a few days I found six chrysalides, and some days later there were six ordinary house-flies buzzing within the tumbler. I then examined the dark chrysalis of the *P. erythronius*, which was evidently dead, and found it only a *shell*. All its interior had been consumed by the six maggots. It is evident that these maggots in their infant stage had already been in the body of the caterpillar when I boxed it. The latter had gone through its transformation as if nothing was the matter with it, although, if one could have interrogated it, probably it would have complained of mysterious gnawings and creepings in its interior. A time, of course, came when, for want of nerve-centres and other organs, the chrysalis could not go on with its development into the perfect Papilio. The six maggots having had a full meal, found their way out of the Papilio's chrysalis in order to undergo *their* transformation.

I knew that the larvæ of the Ichneumonidæ fed on the live bodies of caterpillars, but I did not know that the larvæ of the house-fly did so also. E. BONAVIA

Etawah, India, October 18

THE CRYSTALLINE ROCKS OF THE SCOTTISH HIGHLANDS

EVER since the discovery of Silurian fossils in the rocks of North-West Sutherland, it has been recognised that in that region lies the key to the structure of the Scottish Highlands. Accordingly, when in the progress of the Geological Survey, the mapping of the Highlands had to be undertaken, I determined that a detailed survey of the Sutherland ground on the scale of six inches to a mile should be made as a basis for the work. In the summer of last year a surveying party under the charge of Mr. B. N. Peach was stationed there, with instructions to begin by mapping the Durness Basin. This duty was satisfactorily accomplished before the end of the season. The Silurian series of Durness was ascertained to be about 2000 feet thick, and to consist of numerous successive zones, which were traced on the six-inch maps and discriminated in such a way as to be recognisable should they be found to occur in the more complicated region to the east. With this necessary groundwork well established, the Eriboll tract was attacked this summer by Messrs. Peach and Horne. I had never myself had an opportunity of studying the Eriboll sections, which, from the days of Macculloch down to the present time, have been such a fruitful subject of discussion. It was a special injunction to the officers now intrusted with the detailed survey of the region to divest themselves of any prepossessions in favour of published views and to map the actual facts in entire disregard of theory. By the close of this last season the structure of the Eriboll area had likewise been traced upon the six-inch maps, and I then went north to inspect the work. From time

to time during the summer, reports had been made to me of the progress of the survey, but, though from the published descriptions of that tract, I was aware that its structure must be singularly complicated, and although apprised of the conclusions to which the surveyors, step by step and almost against their will, had been driven, I was hardly prepared for the extraordinary geological structure which the ground itself presented, or for the great change necessitated in the interpretation of the sections as given by Murchison.

No one cursorily visiting the ground could form any notion of its extraordinary complication, which could only be satisfactorily unravelled by patient detailed mapping such as had never yet been bestowed upon it. With every desire to follow the interpretation of my late chief, I criticised minutely each detail of the work upon the ground ; but I found the evidence altogether overwhelming against the upward succession which Murchison believed to exist in Eriboll from the base of the Silurian strata into an upper conformable series of schists and gneisses. The nature of this evidence will be best understood from the subjoined report, which, at my request, Messrs. Peach and Horne have prepared. As the question of the succession of the rocks in the North-West Highlands is still under discussion, I think it right to take the earliest opportunity of making this public declaration. It would require more space than can be given in these pages to do justice to the views of those geologists, from Nicol downwards, by whom Murchison's sections have been criticised, and to show how far the conclusions to which the Geological Survey has been led, have been anticipated. When the official memoirs are published, full reference will be given to the work of previous observers, to which, therefore, no further allusion is made at present.

The most remarkable features in the Eriboll area are the prodigious terrestrial displacements, to which there is certainly no parallel in Britain. Beginning with gentle foldings of the rocks, we trace these becoming increasingly steeper on their western fronts, until they are disrupted and the eastern limb is pushed westwards. By a system of reversed faults, a group of strata is made to cover a great breadth of ground and actually to overlie higher members of the same series. The most extraordinary dislocations, however, are those to which for distinction we have given the name of Thrust-planes. They are strictly reversed faults, but with so low a hade that the rocks on their up-throw side have been, as it were, pushed horizontally forward. The distance to which this horizontal displacement has reached is almost incredible. In Durness, for example, the overlying schists have certainly been thrust westwards across all the other rocks for at least ten miles. In fact, these thrust-planes, but for the clear evidence of such sections as those of Loch Eriboll, could not be distinguished from ordinary stratification-planes, like which they have been plicated, faulted, and denuded. Here and there, as a result of denudation, a portion of one of them appears capping a hill-top. One almost refuses to believe that the little outlier on the summit does not lie normally on the rocks below it, but on a nearly horizontal fault by which it has been moved into its place. Masses of the Archæan gneiss have thus been thrust up through the younger rocks and pushed far over their edges. When a geologist finds vertical beds of gneiss overlying gently inclined sheets of fossiliferous quartzite, shale, and limestone, he may be excused if he begins to wonder whether he himself is not really standing on his head.

The general trend of all these foldings and ruptures is from north-north-east to south-south-west, and the steep westward fronts of the folds show that the terrestrial movement came from east-south-east. Corroborative evidence that this was the direction of the movement is furnished by a series of remarkable internal rearrangements that have been superinduced upon the rocks. Throughout the whole region, in almost every mass of rock, altogether irrespective of its lithological characters and its structure, striated planes may be noticed which are approximately parallel with the thrust-planes, and are covered with a fine parallel lineation, running in a west-north-west and east-south-east direction. These surfaces have evidently been produced by shearing. Again, many of the rocks near the thrust-planes, and for a long way above them, are marked by a peculiar streaked structure which reminds one of the fluxion-lines of an eruptive rock. The coarse pegmatites in the gneiss, for example, as they come within the influence of the shearing, have had their flesh-coloured feldspar and milky-quartz crushed and drawn out into fine parallel laminæ till they assume the aspect of a rhyolite in which fluxion-structure has been exceptionally well developed. The gneiss itself coming into the same powerful mill has acquired a new schistosity parallel with the shearing-planes. Hornblende-rock has been converted into hornblende-schist. Moreover, new minerals have likewise made their appearance along the new divisional planes, and in many cases their longer axes are ranged in the same dominant direction from east-south-east to west-north-west.

Murchison believed that the Silurian quartzites and limestones of Eriboll pass up under, and are conformably overlain by, his upper gneiss. It is quite true that they are so overlain ; but the overlying rocks, instead of having been regularly deposited on them, have been pushed over them. What, then, are these overlying rocks? Though they have undergone such intense alteration during the process by which they were moved into their present position that their original characters have been in great measure effaced, lenticular bands occur in them which can certainly be recognised. Some of these bands are unquestionably parts of the Archæan gneiss ; others are Silurian quartzite, and in one case we can detect a large mass of the Upper Durness limestone. Traced eastwards, however, the crystalline characters become more and more pronounced until we cannot tell, at least from examination in the field, what the rocks may originally have been. They are now fine flaggy micaceous gneisses and mica-schists, which certainly could not have been developed out of any such Archæan gneiss as is now visible to the west. Whether they consist in part of higher members of the Silurian series in a metamorphic condition remains to be seen. The occurrence of a band of crystalline limestone and calcareous schist, which has been traced for many miles above the great thrust-plane, certainly suggests that it represents the upper part of the calcareous Durness series attenuated and altered by the intense shearing which all the rocks have undergone. This much at least is certain, that the schistose series above the thrust-plane is partly made up of Silurian strata, and has received its present dip and foliation since Silurian time.

Having satisfied myself that Murchison's explanation of the order of sequence could not be established in Eriboll, I was desirous to see again, in the new light now obtained, some of the Ross-shire sections for the description of which I am responsible. Had these sections been planned for the purpose of deception they could not have been more skilfully devised. The parallelism of dip and strike between the Silurian strata and the overlying schists is so complete as to prove the most intimate relationship between them ; and no one coming first to this ground would suspect that what appears to be a normal stratigraphical sequence is not really so. But the clear coast-sections of Eriboll, where every dislocation is laid bare, have now taught me that I have been mistaken, for the parallelism in question is not due to conformable deposition. The same kind of evidence of upthrust and metamorphism which these coast-sections reveal can be traced southwards for a distance of more

than ninety miles. The task of unravelling the geological structure of these southern regions will be much facilitated by the remarkable persistence of the Sutherland Silurian zones, some of which, with their characteristic features and fossils, are as well marked above Loch Carron as they are at Loch Eriboll.

In south-western Ross-shire the platform on which the Silurian rocks rest is a thick mass of Cambrian red sandstone. In the great upthrow, it is this sandstone platform which has there been pushed over the limestones and quartzites. On the west side of Loch Keeshorn, the red sandstones, in their normal unaltered form, rise up into the colossal pyramids of Applecross; but on the east side, where, at a distance of little more than a mile, they overlie the limestones, they bear so indurated an aspect that they have naturally been classed with the quartzose members of the Silurian series. Traced eastwards they present increasing evidence of intense shearing; fluxion-structure makes its appearance in them, with a development of mica along the divisional planes, until they pass into frilled micaceous schist, in which, however, the original clastic grains are still recognisable. They finally shade upwards into green schists and fine gneiss which merge into coarse gneiss with pegmatite. The short space within which ordinary red feldspathic sandstone and arkose acquire the characters of true schists is a point of some importance in regard to the change from the unaltered Silurian strata of the Southern Uplands into the metamorphic condition of the Highland phyllites, grits, &c.

Obviously the question of chief importance in connection with the structure now ascertained to characterise the North-West Highlands relates to metamorphism. That there is no longer any evidence of a regular conformable passage from fossiliferous Silurian quartzites, shales, and limestones upwards into crystalline schists, which were supposed to be metamorphosed Silurian sediments, must be frankly admitted. But in exchange for this abandoned belief, we are presented with startling new evidence of regional metamorphism on a colossal scale, and are admitted some way into the secret of the processes whereby it has been produced.

From the remarkably constant relation between the dip of the Silurian strata and the inclination of their reversed faults, no matter into what various positions the two structures may have been thrown, it is tolerably clear that these dislocations took place before the strata had been seriously disturbed. The persistent parallelism of the faults and of the prevailing north-easterly strike of the rocks indicates that the faulting and tilting were parts of one continuous process. The same dominant north-easterly strike extends across the whole Highlands, and also over the Silurian tracts of Southern Scotland and the North of England. There is reason to regard it in all these regions as probably due to one great series of terrestrial movements. These must have occurred some time between an early part of the Silurian period and that portion of the Old Red Sandstone period represented by the breccias and conglomerates of the Highlands. In the Central and Eastern Highlands the slates, phyllites, grits, quartzites, and limestones which, along the southern border, are scarcely more altered than their probable equivalents among the Silurian rocks of the Southern Uplands, have been greatly plicated, and have assumed a more or less crystalline structure. But when these changes were brought about, there lay to the north-west a solid ridge of Archæan gneiss and Cambrian sandstone which offered strong resistance to the plication. The thrust from the eastward against this ridge must have been of the most gigantic kind, for huge slices, hundreds of feet in thickness, were shorn off from the quartzites, limestones, red sandstones, and gneiss, and were pushed for miles to the westward. During this process, all the rocks driven forward by it had their original structure more or less completely effaced. New planes, generally parallel with the surfaces of movement, were developed in them, and along these new planes a rearrangement and recrystallisation of mineral constituents took place, resulting in the production of crystalline schists. This metamorphism certainly occurred after early Silurian times, for Cambrian and Lower Silurian strata, as well as Archæan rocks, have been involved in it.

It is obvious that into the problems of Highland geology, always admittedly obscure, a fresh element of difficulty is introduced. At the same time the aid furnished by a minute study of the Sutherland sections is so great that we may hope to attack these problems with more success than has hitherto seemed probable. The work, too, is not of a kind to be attempted in a few hasty scampers over the ground. It will require patient detailed mapping. But when the great base-lines have once been accurately traced, the difficulties will doubtless begin to diminish, and, like the pieces of a puzzle, the various segments of the Highlands will then be found to range themselves in their proper places. ARCH. GEIKIE

Report on the Geology of the North-West of Sutherland

IN the north-west of Sutherland the most ancient rocks belong to the Archæan series, and present a great uniformity in lithological characters. They consist mainly of coarse hornblendic gneiss, with distinct zones of gray and pink granitoid gneiss, in which the mica is more abundant than the hornblende. Lenticular veins and bosses of hornblende-rock and hornblende-schist, some at least of which are evidently intrusive, occur in the gneiss, while the presence of small kernels of cleavable hornblende and actinolite forms another characteristic feature of the series. Veins of pink or white pegmatite abound, sometimes parallel with the foliation of the gneiss and sometimes traversing it in all directions. These, however, are distinct from dykes of pink granite, which also intersect the gneiss and coarse pegmatites, and are themselves crossed by later pegmatite-veins. Here and there, indeed, the branches of a pegmatite-vein can be seen to return upon themselves and traverse the main trunk from which they start. Where the Archæan rocks have been recently stripped of their former cover of Silurian quartzite, bands of green epidotic gneiss appear among them, and a soft green mineral with a greasy lustre (agalmatolite ?) is there characteristic of the superficial parts of the pegmatite-veins.

The highly crystalline Archæan rocks are overlain unconformably by a succession of conglomerates, grits, and sandstones, regarded by Murchison as the equivalents of the Cambrian system of Wales. In the course of the work of the Geological Survey in the present region they have been divided into certain zones, which, though they need not be stated here, as they have no bearing on the main question to which this paper is devoted, may prove to be of considerable importance in unravelling the geological structure of the districts further south.

Between the Cambrian sandstones and the overlying quartzites at the base of the Silurian series there is a complete discordance. To the west of the Kyle of Durness, for example, the Cambrian sandstones dip to the north-west, while the overlying quartzites dip to the south of east. Moreover, as the observer passes eastwards to the shores of the Kyle, the Cambrian sandstones are bed after bed transgressed by the quartzites, which eventually rest directly on the Archæan gneiss. The Silurian strata in the Durness area (A in Section) consist of a calcareous series at the top; a middle series, composed partly of calcareous and partly of arenaceous strata; and an arenaceous series at the base. The various sub divisions of the strata are given in descending order in the subjoined tabular statement.